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Title: Some Guidelines on Writing a Technical Paper

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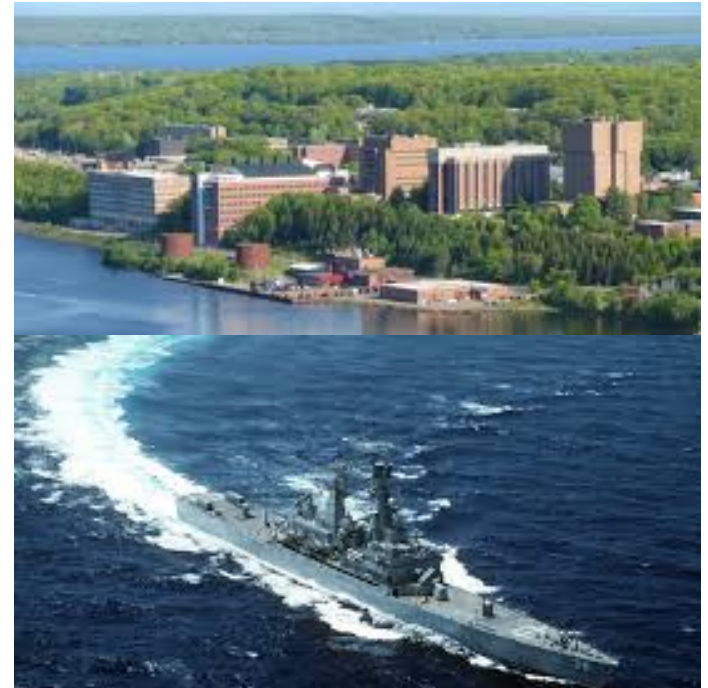
LADSS 2019

**Some Guidelines
on
Writing a Technical Paper**

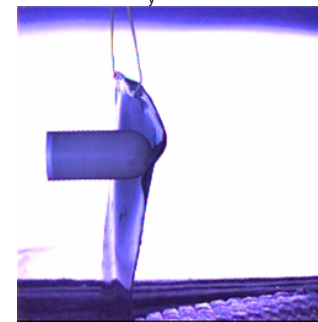
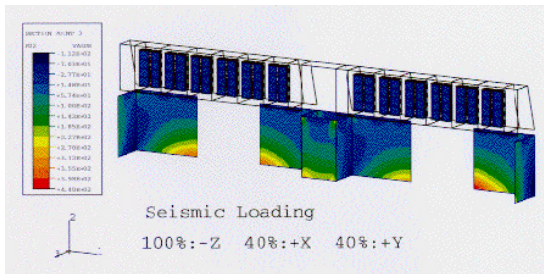
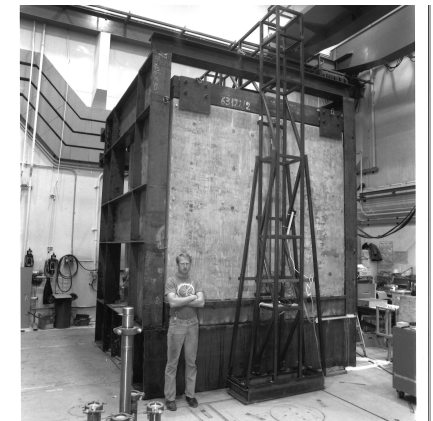
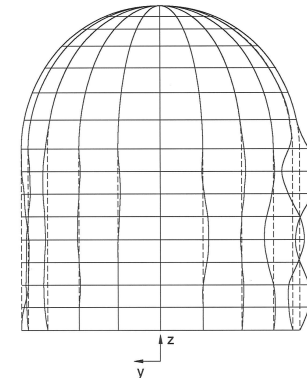
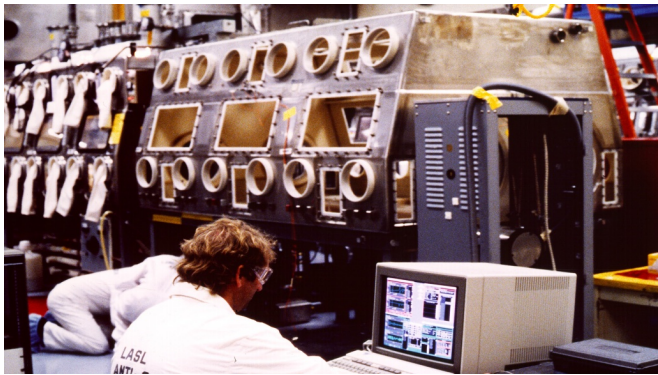
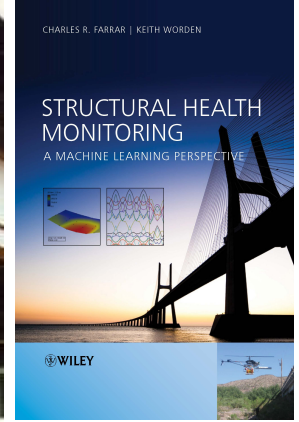
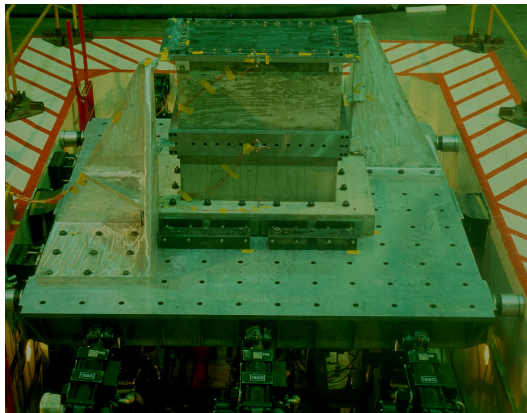
Chuck Farrar
The Engineering Institute

My Background

- From a Maryland suburb of Washington DC
- BS Civil Engineering, Michigan Technological University (decision to go there was based on basketball)
- Two years doing repair and maintenance of nuclear reactors on guided missile cruisers and aircraft carriers at Norfolk Naval Shipyard
- MS Civil Engineering, University of New Mexico (decision to go there was based on a backpacking trip in the Pecos Wilderness)
- Started at LANL as a GRA in 1983 and converted to staff within a year.
- Ph.D. Civil Engineering, University of New Mexico while working at LANL.
- Primarily involved in analytical and experimental structural dynamics my entire LANL career.
- Founded LADSS in 2000.
- Engineering Institute Leader since 2003.



While at LANL I've work on a lot of different structural dynamics project: 1983-1991:earthquake engineering, 1993- 2001 weapons engineering, 1992 – present structural health monitoring, 2002 –present Engineering Institute



Writing will be a big part of your engineering career!

- Undergrad students
 - Lab reports, Capstone projects, Internship & job applications, fellowship and scholarship applications
- Grad students
 - Theses and dissertations, **Technical conference papers**, refereed journal papers, progress reports to research sponsors and/or advisor
- Table below summarizes the different types of writing assignments I've been involved with:

Progress reports to sponsors	Tutorials	Articles for popular press
Technical specifications and procedures executed by technicians	Letters of recommendation and nominations for professional society awards	Letters of recommendation for promotions and tenure
Letters of reference for grad school applications & fellowships	Letters of reference for employment	Technical reviews (journal articles, proposals)
Research funding proposals	Technical conference paper	Congressional testimony
Project and management reviews	Book, Book chapters	Letter of intent
Technical reports to sponsor	Contract specifications and evaluations	Program plan & summary
Refereed journal articles	Literature reviews	Editorials
Web pages	Brochures	Letters of exception

What is engineering?

- **Engineering** is the process of transforming basic scientific discovery into tools and using those tools to solve problems
 - Hardware (dental X-ray machine)
 - Software (simulate car crash dynamics)
- **Engineering** uses the tools available today to solve current problems
- **Engineering Research** focuses on developing new tools based on evolving scientific discovery.



Why do we write technical papers?

- Technical papers are one of the primary ways for researchers to disseminate their results to the broader technical community.
- Three general types of technical publications
 - Refereed journal articles
 - Very rigorous review process
 - In theory, it must contain a “new” contribution to the field
 - Conference paper (we’ll focus on this one)
 - Review process varies widely (from almost none, to that very similar to journal articles) and varies by discipline.
 - Not as strict on the new contribution requirement. Often its O.K to report new applications or even work in progress.
 - Might have very restrictive page limitations set by conference organizers.
 - Technical reports
 - Review process varies (none to very rigorous)
 - Often much more detailed and can include things that didn’t work
 - May have limited distribution (companies might want to document results, but not disseminate results, e.g. LANL’s classified work)

Getting a Paper Accepted at a Conference

- In most cases, papers are accepted for presentation at a conference based on the submission of an abstract (more on abstracts in a few slides).
- Abstract submission typically occurs about 6-9 months before the conference.
- This timing often results in abstract being submitted before the work has been completed.
- Once the abstract has been accepted, then a paper usually is submitted and subsequently published in the conference proceedings.
- Finally, you will need to distill your paper into an oral presentation that is presented at the conference. (covered in Phil Cornwell's presentation last week)
- Many conferences also have invited papers, but these are usually requested by the organizers from more senior people in the field or people doing leading work on “hot topics”.

Components of a technical paper

- Abstract
- Introduction
- Description/derivation of the proposed method (AKA Theory, Methodology, Approach)
- Analytical verification (demonstration of the method on problem with known outcome, often analytically generated)
- Experimental validation (demonstration of the method on a physical system)
- Summary and conclusions
- Acknowledgements
- References

Abstract

- There are two possible abstracts:
 - The one you submit to the conference organizer to get your paper accepted. **Goal:** get your paper accepted by the organizing committee. Show that your work fits the conference theme topics.
 - The one you have at the beginning of your paper **Goal:** get people interested in your work so they are motivated to read the rest of the paper.
- In either case, the abstract is a **concise, high-level** summary of your project. It should contain:
 - A definition of the problem you are studying and why its important
 - The new approach you took or the new application
 - The results you obtained (or anticipate, if you haven't done the work)
 - New contribution you have made or anticipate making.
- Because the abstract is written at a high level, in general, it should not be a cut and paste from the main body of your paper.
- If it accurately summarizes what is in your paper, the abstract you submit to the conference for acceptance and the one at the start of your paper can be the same.
- Use the abstracts of papers you are reading for your literature review as examples.
- Typically, an abstract is on the order of 150 – 300 words in length. The conference call for paper submissions might specify a length.
- The abstract is often the last section of the paper that is written.
- There are no citations in an abstract

Introduction

- Define the problem you are solving,
 - What are you trying to do?
 - Defines limitations on the scope of your study
 - **Capture the reader's attention in the first paragraph!**
- Define why this problem is important, interesting and/or challenging
 - What is motivating you to study this problem?
 - But consider your audience, if you're at a structural health monitoring conference, you don't have to convince people why SHM is important.
- Define what has previously been done to address this problem,
 - How is it solved (or not) today
 - **What are the limitations of current approaches**
 - This definition is usually done through some form of a concise summary of other related work that has been reported in journals and previous conferences (AKA a **Literature Review**)
 - This discussion helps to justify any statement regarding your new and unique contributions
- Introduce at a high level your new solution procedure, how it addresses shortcoming identified with previous work and what is **novel** about it.
- Often the introduction concludes with a brief summary or outline of what is contained in the rest of the paper.
- After reading the introduction the reader should have a pretty good idea of what your paper is addressing, and at a high level how you are going to address it.
- You may need to modify the introduction as your study progress.

Literature Review

- This portion of the paper, which is usually part of the introduction, is simply a summary of what others have done related to your problem.
- It should help to differentiate your work from previous work (e.g. show that you are providing a new methodology or reporting on a new application)
- In most cases, because of length limitations, it will be impractical to mention all the applicable literature.
 - Some refereed journal articles are simply exhaustive literature reviews.
 - Only summarize what you consider to be the most relevant works.
 - Cite other relevant literature reviews.
- A goal of the literature review is to give the readers confidence that you know what the state-of-the-technology is related to your research topic.

Derivation/Development of the new contribution (AKA Methodology or Theory)

- This section of the paper describes in detail the new technology (hardware, software, or both) you are presenting.
- It should be clear how your technology is going beyond what has previously been done.
- There should be a clear statement of any limiting assumptions that your technology is based on.
- I think its best to start with a heuristic explanation of what you are doing and then provide a more rigorous development that includes the mathematical details.
- Make use of sub-headings to help guide the reader through the development of the new technology.
- Every term in every equation that you use must be defined no matter how common the equation is.
- Tell the read **what** you have developed and also tell them **why** it works.

Analytical Verification (AKA Analysis and/or Results)

- In this section you should demonstrate the new technology you have proposed on a problem with a known solution.
 - Provide the reader confidence that your approach actually works
 - Provide the reader confidence that you have implemented your technology correctly (**i.e. you're solving the equations right**).
 - Make extensive use of well-documented, stand-alone graphs, tables and/or figures

Experimental Validation (AKA Analytis and/or Results)

- In this section, you should demonstrate that you technology works in a “real-world” environment.
 - Show that the proposed methodology works under more challenging circumstances with added sources of uncertainty/variability
 - Provide the reader confidence that you are solving the problem your first proposed (**i.e. your solving the right equations**)
 - Make extensive use of well-documented, stand-alone graphs, tables and/or figures.

Summary and Conclusions

- This section of the paper should be a succinct wrap-up of the study highlighting the significant results obtained.
- This section should tie directly back to the motivation for the study stated in the introduction and how you have addressed the shortcomings of previous work that were identified in the literature review.
- There should be no statement in the conclusions that can not be supported by material presented in the main body of the paper.
- Restate the unique contribution you have made, now backed up by the results you have obtained.
- You can include a brief discussion of outstanding research issues and possible future work.

Acknowledgements & References

- Typically, you put a short statement at the end of the paper acknowledging the funding source and others who might have helped with various aspects of the study, but were not actual participants on the project. You might also acknowledge organizations that provided things at no cost like sample hardware or freeware.
- Acknowledgement Example:

Funding for this research was provided by the Los Alamos National Laboratory through the Laboratory Directed Research and Develop program. The authors thank Drs. Dave Higdon and Todd Graves for facilitating and encouraging the research collaboration between the LANL's Statistical Sciences Group and the Engineering Institute. Additionally, the authors wish to acknowledge the technical collaborations with Prof. Keith Worden at the University of Sheffield and his valuable comments and suggestions regarding this work.

- Papers usually end with a list of cited references (this is not a bibliography).
 - The format for the individual citations and the list might be specified in the paper preparation instructions.
 - It is probably most common to list the papers in the order they are cited.
 - Sometime papers are listed in alphabetical order by first author's last name.
 - Do not include references that were not cited in the main body of your paper.
 - Typically, you do not use footnotes for citations

Attributes of a Good Paper

- Writing is precise, unambiguous and keeps in mind that the reader is not as intimately familiar with the material as the author.
- The goals of the study are explicitly stated.
- There is a clear and logical flow to the material presented (you've told a complete story).
- The methodology and supporting verification and validation studies are clearly developed and documented and support by well-annotated, stand-alone tables, graphs and figures.
- The end results and limitations of the study are clearly stated.
 - Note page limitations and time restrictions on the oral presentation make it difficult to discuss negative results

Things You Shouldn't Do

- Speak negatively of anyone else's work.
 - Stating a limitation of previous work is not speaking negatively if it is done in a matter of fact manner.
- Insult the reader with terms like “clearly”, “easily”, “obviously”, and “trivially”,
- Overstate the results that have been obtained.
- Make any statements about commercial aspects of a study. The paper shouldn't be a sales job.
- Show any bias

Common Editorial & Style Mistakes

(based on correction to my writing provided by LANL technical editors)

Make sure all tables, figures and references are referred to in the main text.

These figures should be placed after the paragraph where they are first mentioned.

Do not start a sentence with “This” and then omit the subject. All sentences need a subject and a verb.

Example:

“This can be the result of energy dissipation within the material” should read
“This observed response can be the result of energy dissipation within the material.”

You must use S.I. units.

Even if you developed your experiment using English units you still need to describe it with S.I. units. Dual units are acceptable with one set of units in parentheses.

Figures must reproduce in black and white or gray scale if the document will be printed. Color is O.K. for electronic documents.

Common Editorial & Style Mistakes

Proper use of “Since” and “Because”. Since should refer to time, e.g. “Since the founding of our nation ...”

Misuse of since: “Since the mode shapes corresponding to this frequency indicated that Mass 2 experienced the greatest motion, ...” in this example Here *Since* should be replaced with *Because*.

Proper use of “due to” and “because of” or “as a result of” or “caused by” LANL technical editors have told me that “due to” refers to owing money. The rent is *due to* the landlord at the end of the month. According to them, something like “the drop in resonant frequencies was *due to* the added mass” should be “the drop in the resonant frequencies was *caused by* the added mass”

All graphs must have their axes labeled and the units identified.

The word “data” is plural, datum is singular.

“The data that *was* collected....” Should read “The data that **were** collected.”

Common Editorial & Style Mistakes

Repetitive use of the same word or word form in a sentence:

“The floor plates were modeled *with* shell elements *with* material properties of aluminum.” Should read

“The floor plates were modeled with shell elements *using* aluminum material properties.”

Unnecessary use of the preposition “of;”

“The floor plates were modeled with shell elements with *material properties of aluminum.*” Should read

“The floor plates were modeled with shell elements using *aluminum material properties.*”

Keep sentence structure as simple as possible. If possible, minimize the use of hyphens, semi-colons and parentheses.

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Keep sentence structure as simple as possible. If possible, minimize the use of hyphens, semi-colons and parentheses.

Common Editorial & Style Mistakes

Avoid the use of relative terms. Quantify all descriptions of experiments, analyses and results

A **large** beam was used to ... "*large*" is a relative term, the statement should read:

A 5-cm-square beam 2-m-long was used to...

The first calculated modal frequency **agreed well** with the first measured modal frequency. "*agreed well*" is a relative term, the sentence should read:

The first calculated modal frequency was two percent greater than the first measured modal frequency.

Although there is not a definitive standard, I recommend using the third person in your writing. No I, we, our, etc.

Try to avoid using the passive form when it can be changed easily.

"It is demonstrated by the example that the algorithm provides an accurate solution." Should read: "The example demonstrates that the algorithm provides an accurate solution."

Every sentence must have a subject and a verb! Listed below is an IMAC Abstract that violated this rule:

"Examination of modal parameters for a flat plate for four cases: freely suspended, plate freely suspended while supported by an oil film, plate fixed at several locations, and plate fixed at several locations while supported by an oil film. Investigation of the bending properties of a square plate on a slip table, particularity with consideration of dampening provided by an oil film. Comparison of support and dampening characteristics supplied by an oil film with that provided by equally placed linear bearings. Analytical and empirical data is contrasted and discrepancies discussed."

Common Editorial & Style Mistakes

Consistent number of significant figures. In the following table mode 1 resonant frequency is reported to 3 significant figures while the higher resonant frequencies are reported to 5 significant figures implying that the higher resonant frequencies can be estimated with much great accuracy. Note that it may require a detailed statistical analysis to determine just how many significant figures can accurately be reported.

Table 1: Frequencies (Hz) of mode shapes from experimental data and finite element model

Mode number	Experimental	FE Model
1	2.29	3.03
2	3.04	3.87
3	12.57	6.76
4	13.90	7.27
13	120.33	126.27
14	138.89	130.10

Don't use “etc.” when making a list in a technical document. “Etc.” implies that the reader knows what you're thinking. **Technical writing is about being precise** and it's not good to assume the reader knows what you're thinking. If it's important, spell it out. If it's not important, leave etc. out of a list.

Closing Comments

Note, depending on the nature of your study and length limitations on the paper and presentation, you may not be able to address all the paper sections discussed in this presentation.

In theory, a reader should be able to replicate your work based on the methodology and results documented in your paper.

Technical papers are the primary communication mechanism for engineering research and technical development.

Precision in your writing is key to this communication!